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FORM PTO-1390 (Modified) (REV 11-2000) U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY'S DOCKET NUMBER
218239US2PCT

U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR
10/030990

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/CA00/00722	**15 JUNE 2000**	**16 JULY 1999**

TITLE OF INVENTION

INFRARED HEATER WITH ELECTROMAGNETIC INDUCTION

APPLICANT(S) FOR DO/EO/US

Normand BEDARD, et al.

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include itens (5), (6), (9) and (24) indicated below.
4. ☒ The US has been elected by the expiration of 19 months from the priority date (Article 31).
5. ☒ A copy of the International Application as filed (35 U.S.C. 371 (c) (2))
   a. ☐ is attached hereto (required only if not communicated by the International Bureau).
   b. ☒ has been communicated by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☐ An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
   a. ☐ is attached hereto.
   b. ☐ has been previously submitted under 35 U.S.C. 154(d)(4).
7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371 (c)(3))
   a. ☐ are attached hereto (required only if not communicated by the International Bureau).
   b. ☐ have been communicated by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☒ have not been made and will not be made.
8. ☐ An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☐ An oath or declaration of the inventor(s) (35 U.S.C. 371 (c)(4)).
10. ☐ An English language translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371 (c)(5)).
11. ☐ A copy of the International Preliminary Examination Report (PCT/IPEA/409).
12. ☒ A copy of the International Search Report (PCT/ISA/210).

Items 13 to 20 below concern document(s) or information included:

13. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
14. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
15. ☐ A **FIRST** preliminary amendment.
16. ☐ A **SECOND** or **SUBSEQUENT** preliminary amendment.
17. ☐ A substitute specification.
18. ☐ A change of power of attorney and/or address letter.
19. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825.
20. ☐ A second copy of the published international application under 35 U.S.C. 154(d)(4).
21. ☐ A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).
22. ☐ Certificate of Mailing by Express Mail
23. ☒ Other items or information:

    Notice of Priority
    PTO-1449

U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR	INTERNATIONAL APPLICATION NO.	ATTORNEY'S DOCKET NUMBER
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24. The following fees are submitted:.

BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)) :

		CALCULATIONS	PTO USE ONLY
☐ Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO	$1040.00		
☒ International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO	$890.00		
☐ International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO	$740.00		
☐ International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4)	$710.00		
☐ International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4)	$100.00		
ENTER APPROPRIATE BASIC FEE AMOUNT =		$890.00	
Surcharge of **$130.00** for furnishing the oath or declaration later than ☐ 20 ☒ 30 months from the earliest claimed priority date (37 CFR 1.492 (e)).		$130.00	

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total claims	- 20 =	0	x $18.00	$0.00	
Independent claims	- 3 =	0	x $84.00	$0.00	
Multiple Dependent Claims **(check if applicable)**.			☐	$0.00	
TOTAL OF ABOVE CALCULATIONS =				$1,020.00	
☐ Applicant claims small entity status. See 37 CFR 1.27). The fees indicated above are reduced by 1/2.				$0.00	
SUBTOTAL =				$1,020.00	
Processing fee of **$130.00** for furnishing the English translation later than ☐ 20 ☒ 30 months from the earliest claimed priority date (37 CFR 1.492 (f)). +				$130.00	
TOTAL NATIONAL FEE =				$1,150.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31) **(check if applicable)**.			☐	$0.00	
TOTAL FEES ENCLOSED =				$1,150.00	
				Amount to be: refunded	$
				charged	$

a. ☒ A check in the amount of **$1,150.00** to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. ______________ in the amount of ______________ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. **15-0030** A duplicate copy of this sheet is enclosed.

d. ☐ Fees are to be charged to a credit card. **WARNING:** Information on this form may become public. **Credit card information should not be included on this form.** Provide credit card information and authorization on PTO-2038.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

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24,913

REGISTRATION NUMBER

Jan 16 2002

DATE

Received at: 11:58AM, 9/3/2002
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INFRARED HEATER WITH ELECTROMAGNETIC INDUCTION

TECHNICAL FIELD

The invention concerns an infrared heater with electromagnetic induction. More particularly, the invention relates to a device capable of emitting infrared radiation, said device being electrically supplied by means of a field winding and characterized by a choice of material for the heater that is adapted to withstand high temperatures and to reach high power density radiation power of the middle type.

PRIOR ART

In most of the many applications of electrical infrared, the power density needed with the process is relatively low. On the other hand, some processes such as coated paper drying in the pulp and paper industry require the use of technologies with very high power density. This requirement is due to the fact that machines are running sheets of paper at high speeds and evaporation is relatively high.

Most of the infrared applications in the field of pulp and paper industry concern coating drying. Infrared is used for drying layers on the sheet of paper, mainly since 1985 [Bédard, N., *Evaluation of the Performance of Electric Heaters and Radiant Gas Burners,* CEA report no. 9321 U 986, 1996]. The infrared system is placed directly downstream of the coater, which allows "seal" the coating slip on its paper support. Currently, this technique constitutes a standard since it results in an excellent quality product at high running speeds. The high power density also enables installation on existing machines, where space is limited.

Nearly all the first infrared systems mounted on coaters were electrically powered: they were essentially made of high intensity lamps (emitting a very vivid white light). But, the infrared gas technology slowly emerged and now takes an increasingly important part of the market. Today, most of the new infrared systems that are installed in the pulp and paper industry are powered with natural gas. Different technologies are available: punched ceramic plates, ceramic or metallic fibers matrices, cross-linked ceramic and the like.

The main reason for the success of the infrared technology gas is obviously the gross price of this source of energy. The ratio between the price of gas and that of electricity in large industries is about 1 to 3 in Québec and may reach up 1 to 5 and even more in the United States. The sturdiness of gas radiation devices is also appreciated when compared to high intensity lamps, which are reputed to be quite fragile.

Often, the higher cost for electricity as compared to gas is compensated by a better efficiency of electrical technologies. If one considers the radiation efficiency only, i.e. the total radiation power versus consumed power, one could conclude that this is the case in the field of infrared applied to the pulp and paper industry. Indeed, this efficiency is typically 80% for short infrared units and 45% for gas radiation devices. These values were in any case precisely measured during the same test within the framework of an important project of the Association Canadienne de l'Électricité (Canadian Association of Electricity) [idem]. However, this efficiency does not account for what takes place at the paper level, because the really useful part of the consumed power is what is actually found inside the coated paper. The absorption properties of the paper and the coating slip should therefore be taken into consideration. But these properties vary depending on certain ranges of wavelengths.

The temperature of gas emission radiating systems is between 900 and 1150°C: radiation is therefore of middle type, i.e. within the wavelengths identified at medium infrared (more than 85% of the power radiated between 1 and 6 m). They present radiation power densities of 100 to 160 kW/m^2. Lamp type electrical heaters (in which the filament reaches 2200°C) provide more radiation within the short wave infrared (more than 85% of the power radiated between 0 and 2.5m) and yielding power densities exceeding 300 kW/m^2.

It is generally recognized that the "middle" infrared type is better adapted for drying paper and coater's coating slip because of the appropriate coupling of their spectral absorption properties and the emission spectrum [Pettersson M., Stenstrom S., *Absorption of Infrared Radiation and the Radiation Transfer Mechanism in Paper, Part II: Application to Infrared Dryers.*, Journal of Pulp and Paper Science: Vol. 24 N° 11, November 1998]. The advantage of a better radiation yield of lamp type electrical systems is therefore diminished, and consequently also that of the power density.

The obvious solution to this problem is of course a middle type electrical infrared (that is with a radiation temperature around 1100°C), already commonly used in many fields (textile, plastic, agro-food). However, the current technology does not permit to reach the same radiation power density as that of gas radiating systems: at the most $80kW/m^2$ with an electrical system compared to $150kWm^2$ with a gas system. This lack of competition for middle type electrical radiation systems leaves the door wide open to gas systems. In fact, gas technology is holding the market of

infrared drying in the pulp and paper industry in North America (300 MW in 1995) and in the world (more than 1000 MW). An electrical infrared technology allowing power densities that are equivalent to gas radiating systems within the middle type infrared would therefore be welcome. Moreover, the market's requirements are seeing for even higher power densities: the emergence of a middle type infrared electrical technology operating at very high power density would open particularly attracting horizons. The availability of such a technology would be even more interesting since gas radiating systems yield decreases with temperature emission, and therefore with the power density, in an inextricable manner [Douspis, M., Robin, J.-P., « Les brûleurs radiants à gaz », document CERUG 86.05]: an electrical technology having a radiating power density over 200 kW/m2 would then be very competitive (at an equivalent power density, gas radiating systems have a radiation yield of less than 35%).

As will be seen later the current electrical middle type infrared technology is limited in power density and an object of the present invention is therefore to overcome these limitations.

Typically, an infrared source consists of a solid body that is raised to such a temperature that it emits an electromagnetic radiation of the infrared type. Electrical infrared heaters imply the passage of a direct current through a resistance, normally a metallic wire. Heating is therefore carried by Joule effect (direct electrical conduction).

The power density of a heater comprising a metallic wire is limited for many reasons. Metallic wires have a low electrical resistance and cannot be used at a temperature exceeding 1300°C. To obtain an adequate resistance (i.e. sufficiently high to provide acceptable currents), the diameter should be decreased or the length of the wire should be increased. The wire's life span is therefore decreased as its diameter decreases: consequently, it is better to increase the length of the wire, which is obtained by making a coil. But then, a certain distance between the spires of the same coil and the rows of coils should be maintained otherwise hot points will be produced. This requirement limits the power density.

Moreover, it is often essential to cover the coils with an insulating material protecting them from the environment, from a thermal (in order to limit the losses by convection with ambient air) as well as from electrical (for reasons of security) points

of view. The coiled wires are then embedded or inserted in a material that is pervious or not to infrared radiation.

When dealing with a material that is opaque to infrared, heat must be transmitted from the internal metallic wire to the external cover by direct conduction. It is then this cover that emits infrared radiation and it is maintained at a lower temperature than the internal wire itself. In the case of radiating tubes ("tubular heaters"), an non-conductive material (normally an oxide) must be inserted between the resistance and the cover, which limits heat transfer and produces a high temperature gradient. The power density is thus more limited than with a naked coil.

When an infrared pervious material (normally quartz) is used to contain the coil, radiations originate from the coil itself but pass directly through the quartz. The metallic coil is then protected from movements of surrounding air: losses by convection are thus decreased. The power density of infrared sources consisting of coiled wires embedded in plates or inserted in quartz tubes is the highest among the electrical middle type infrared sources but remains below 100 kW/m^2, providing less than 80 kW/m^2 of radiation.

On the other hand, short infrared lamp sources are characterized by a very high power density, since the tungsten wire inside the lamps is raised to very high temperature (2200°C): however as seen above, this level of temperature implies that the emission is rather of a short type, causing the already mentioned disadvantages. Moreover, the tungsten wire should be enclosed in a sealed tube to prevent a rapid oxidation thereof.

It should be noted that among all metals, no current technology allows to exceed 1300°C in an oxidizing atmosphere for a very long period of time (in terms of years). The only metallic alloy that maintains relatively well this level is made of Iron-Chromium-Aluminum and is mainly manufactured by the Kanthal Company (under the name Kanthal AL). In fact, its mechanical properties are much weakened at that temperature.

Another means for increasing power density is to enlarge the real emission surface by utilizing an expanded surface instead of a coiled wire. A configuration in the form of a full and expanded plate enables to increase the emission surface. In theory, if it would be possible to heat a full surface of Kanthal Al at 1300°C in a relatively uniform fashion, the radiation power density would be very high (above 300 kW/m^2). The difficulty is to make the current pass everywhere through this surface.

While using direct conduction, it is very difficult to produce uniform heating, since current passes through the shorter "electrical" way. In order to make the current pass everywhere through the voltage terminals, several cuts must be made in the plate, which cause mechanical behavior and local concentration current problems. Some means have been evaluated and tested by the Applicant, but several problems have led to question the use of direct electrical conduction: heating uniformity, voltage supply, thermal dilatation, mechanical solidity, thermal losses through contacts, and more.

Following the above considerations, Applicant considered using electromagnetic induction: instead of passing current directly through a resistance, heating can then be carried by Foucault currents induced by a conductor that is physically disconnected from the heated material. Moreover, the material in which these currents are produced may be another material than the metal constituting the coiled wire of conventional infrared sources.

The use of induction instead of direct conduction therefore allows to solve many technical problems.

The choice of the material the emitting surface is made of constitutes the determinant aspect. This material should have the capacity to support very high temperatures, well over the Curie point of all the materials having magnetic properties. Therefore, only resistance plays a part in an electromagnetic point of view. On an other hand, Applicant has managed to identify a range of material resistance and of supply frequencies leading to an excellent electrical yield and a relatively good power factor, two conditions necessary to use the induction as heating mean for an infrared system. It is possible to transfer a very high power (over 50 kW for a plate measuring $0.16m^2$) by generating a typical electrical field, at a reasonable voltage supply. Heating is relatively uniform, in spite of the fact that the current produced in the heating plate takes the form of the inductor's configuration, the latter being in the circular shape ("pancake"): the four corners of the plate are therefore colder, as well as the center. However, this concept enables to prevent problems associated with hot points and losses through the connections associated with direct electrical conduction.

The material the emitting surface is made of should have the capacity to support very high temperatures and thermomechanical stresses. The metals the resistance wires of the infrared sources are made of are characterized by very weakened mechanical properties, in the vicinity of 1300°C, which would prevent them form being used as radiating plate.

A solution that was studied consisted in using electrically conducting ceramic, namely silicon carbide of the "reaction bounded" type. Some variants of this material contain a portion of free silicon allowing a electromagnetic induction heating at a few tens of kilohertz. Induction heating of one square foot plates has shown a good electromagnetic coupling, but has systematically led to thermomechanical breaks. It appears that monolithic type ceramic materials are not suitable: on one hand because thermomechanical stresses produced by an intense and imperfectly uniform heating are in the order of their ultimate mechanical resistance; on the other hand, the currently known processes of manufacturing large plates of monolithic ceramic material produce important residual stresses.

Finally, Applicant realized, as well as others, that ceramic even the most performing such as silicon carbide is fragile to mechanical and thermomechanical stresses.

A relatively recent solution to this traditional problem consists in blending fibers in the ceramic matrix, in order to constitute a « Ceramic Matrix Composite » (CMC). The fact of blending fibers allows to increase the material strength and to eliminate all danger of break according to a catastrophic process: fibers prevent a rapid development of microcracks [Wess J.K., *Breaking Tradition With Ceramic Composites Offer New Features that Traditional Ceramics Lack)*, Chemical Engineering, pp 80 – 82, October 1996].

In an improvement effort, some years ago, a particular type of ceramic composite was developed, i.e. the "Continuous Fiber Ceramic Composites" (CFCC), manufacturing of which implies techniques such as CVI (Chemical Vapor Infiltration) and CVD (Chemical Vapor Deposition).

CFCC's therefore constitute a solution to the traditional problem of ceramic materials fragility. They can operate at high temperature, be subject to thermal stresses, and have an important life span. These advantages make them ideal candidates to be used as the basis of a high power density infrared system. However, most of the CFCC are not electrically conductive, and cannot therefore be heated by electromagnetic induction. Applicant has noted that CFCC including carbon fibers (C/SiC) that are sufficiently electrically conductive to be efficiently heated by electromagnetic induction.

Then, other materials that are continuously developed are carbon/carbon composites that also have a very high resistance to thermal stresses. They are however

limited in terms of temperature since they are oxidized above 600°C. They must therefore be covered with an external protective layer, which is the object of many studies throughout the world. Applicant has verified the excellent response to heating by electromagnetic induction of a C/C plate that is covered with a layer of silicon carbide.

However, the resistance of the anti-oxidizing layer under high temperature of the C/C composites for a prolonged period of time (years) remains a technical problem up to now [Bédard N., *Développement d'un émetteur infrarouge à haute densité de puissance – Rapport d'activités* LTEE-RT-0096/1998]. A solution to this problem would open the door on vast horizons, since the C/C composite itself maintains excellent mechanical properties, even above 2000°C. This temperature would involve power densities exceeding a thousand kilowatt by square meter!

DISCLOSURE OF THE INVENTION

An object of the invention is to produce a radiating surface that is merely made of a suitable material, having the appropriate shape and size, and which electrical, mechanical and thermal characteristics as adequately selected.

Another object of the invention is to rely on induction, which allows to use non-metallic materials, and to obtain a good electrical yield.

It is another object of the invention to reach a limit temperature that is higher than that of Fe – Cr – A base metals, which is 1300°C, and can even exceed 1400°C.

Another object of the invention is to use a composite material having a relatively low electrical resistance as to respond to induction heating.

Another object of the invention is to reach power densities of more than 200 kW/m^2 in middle infrared by utilizing a heater according to the invention.

It is also an object of the invention to use a material that responds to electromagnetic induction and having the capacity to support the operating conditions above-mentioned, for example responding to induction heating.

Another object of the invention is to propose as a material for the heater, composite ceramics that do not have the disadvantages of monolithic type ceramic materials.

In order to overcome the disadvantages described above, Applicant has provided an infrared heater comprising a surface consisting of a material responding to induction and able to support high temperatures, at least one layer of insulating material of very low heat conductivity opposite said surface, an inductor adjacent said

insulating materials layers and separated from said surface by the latter, as well as one field concentrator adjacent to said inductor. The material responding to induction may for example consist of a matrix enabling induction heating and including carbon fibers.

According to a preferred embodiment, the surface reacting to induction is in the form of a plate that can be selected from composite materials namely CFCC and carbon/carbon type.

According to another preferred embodiment, the surface should have the capacity of being heated to a temperature of at least 1300°C, and to produce a radiation power density exceeding 250kW/m^2.

According to another embodiment, the insulating material consists of a layer of low temperature insulating material and a layer of high temperature insulating material.

Then, the inductor may include an inductor consisting of a water cooled copper tube, or it may also include Litz cables.

According to another embodiment, the field concentrator is opposite the inductor.

According to a practical application, the plate has a layer between about 1 mm and 5 mm.

BRIEF DESCRIPTION OF THE INVENTION

Other characteristics and advantages of the invention will appear from an embodiment that is illustrated in the annexed drawings, in which

Figure 1 is a plan view of an infrared induction heater, according to the invention, and

Figure 2 is a cross-section taken along A' – A" of figure 1.

DETAILED DESCRIPTION OF THE INVENTION

With reference to the drawings, the basic configuration of a heater according to the invention is simple as it can be seen. It comprises a plane radiating surface 5 that responds to induction and can resist high temperatures. A preferred material constituting the plane-radiating surface will be described in detail below. This plane surface is opposite a high temperature insulating material 4. Above this high temperature insulating material 4, there is a low temperature insulating material 3. It is understood that the nature of the insulating materials 3, 4 will vary according the needs and the particular choice of the constituting materials will be left to one skilled

in the art. On the other side of the two insulating materials 3, 4 there is an inductor 2 consisting, in the illustrated case of a water cooled copper tube, well known to those skilled in the art. A Litz cable or any other inductor could also very well be used, depending on the choice of one skilled in the art. The inductor is coiled upon itself in a plane. Finally, a field concentrator is mounted opposite the spiraled tubular member (figure 1). As will be seen in figure 2, the infrared heater is mounted to transmit a radiation on a sheet of paper 6.

Applicant has discovered that a CFCC comprising carbon fibers enables to give a plate that is expanded under high temperature to give an middle type infrared radiation with a high power density. Tests have shown that the carbon fibers that are blended within a silicon carbide matrix produce an induction heating at frequencies of some tens of kilohertz. Simulation tests and tests made on a prototype have shown that it would be possible to transfer the power with a very good electrical efficiency. On a thermomechanical point of view, it was possible to observe that this composite have excellent properties. A plate made of CFCC of AlliedSignal Composites had a perfect plane aspect and a good appearance of uniformity. A very intense induction heating led to no breaks, deformation nor reduction of mechanical rigidity. Electromagnetic coupling was also confirmed to be excellent.

To summarize, the invention consists in heating a plate of a specific material by electromagnetic induction, said plate being heated at high temperature, and consequently, produces an infrared radiation. The main temperature of the plate is about 1300°C, which constitutes a source of middle infrared, therefore suitable for drying a coating on paper. At that temperature, and taking into account the emission capacity of the constituting material, the radiation power density exceeds 250 kW/m^2, which would more than double the radiation power density of most of presently known gas radiation means.

This very high power density constitutes the essential aspect of such a system. This represents an occupied surface that is reduced by half for the same power provided therein. Moreover, the concept is characterized by a very reduced vertical crowding as compared to currently know gas and electrical technologies: this is due to the absence of air combustion and gas inlets (with reference to gas radiating means) or cooling air for the connectors (with reference to the short infrared lamp technology). The new concept therefore makes it possible to reduce the space that is occupied horizontally and vertically. The reduced vertical crowding may allow placing

IRHD/induction sources on both sides of the sheet of paper, which would increase even more the power density.

In addition to the pulp and paper industry, the IRHD technology could also find very interesting applications in metallurgy and glass making. In metallurgy, high temperature ovens that are presently heated with radiating tubes could advantageously be replaced by means of induction heated plates. These plates could then be mounted against the internal walls of the oven to give a very high heating capacity, and production. In the glass industry, the infrared power density of medium type is very much required.

CLAIMS

1. Infrared heater comprising a surface consisting of a material responding to induction and capable of withstanding elevated temperatures, at least one layer of insulating material of very low heat conductivity placed against said surface, an inductor adjacent said layers of insulating material and separated from said surface by said layers, and a field concentrator adjacent said inductor.
2. Heater according to claim 1, characterized in that the surface that responds to induction is in the form of a plate.
3. Heater according to claim 2, characterized in that said plate is selected among composite materials.
4. Heater according to claim 3, characterized in that said plate is selected from composite materials of CFCC and carbon/carbon type.
5. Heater according to claim 1, characterized in that the surface responding to induction is a thin layer placed against a plate.
6. Heater according to claim 3, characterized in that said surface is capable of being heated to a temperature of at least 1300°C, and to produce a radiation power density exceeding 250 kW/m^2.
7. Heater according to claim 1, characterized in that the insulating material consist of a layer of a low temperature insulating material and a layer of a high temperature insulating material.
8. Heater according to claim 5, characterized in that the inductor includes a water cooled copper tube.
9. Heater according to claim 5, characterized in that the inductor comprises a Litz cable.
10. Heater according to claim 6, characterized in that the field concentrator is mounted adjacent said inductor.
11. Heater according to claim 4, characterized in that said plate has a thickness between 1 mm and 5 mm.
12. Heater according to claim 1, characterized in that said material consists of a heating matrix and comprising carbon fibers.

ABSTRACT

The invention concerns a heater made of a material (5) responsive to induction and capable of sustaining high temperatures. It further comprises at least an insulating thickness with low thermal conductivity, in particular a low temperature insulation (3) and a high temperature insulation (4), said thickness being fixed at the back of the material. A field winding (2) is adjacent to the insulating thickness and separated from the material (5) by the latter.

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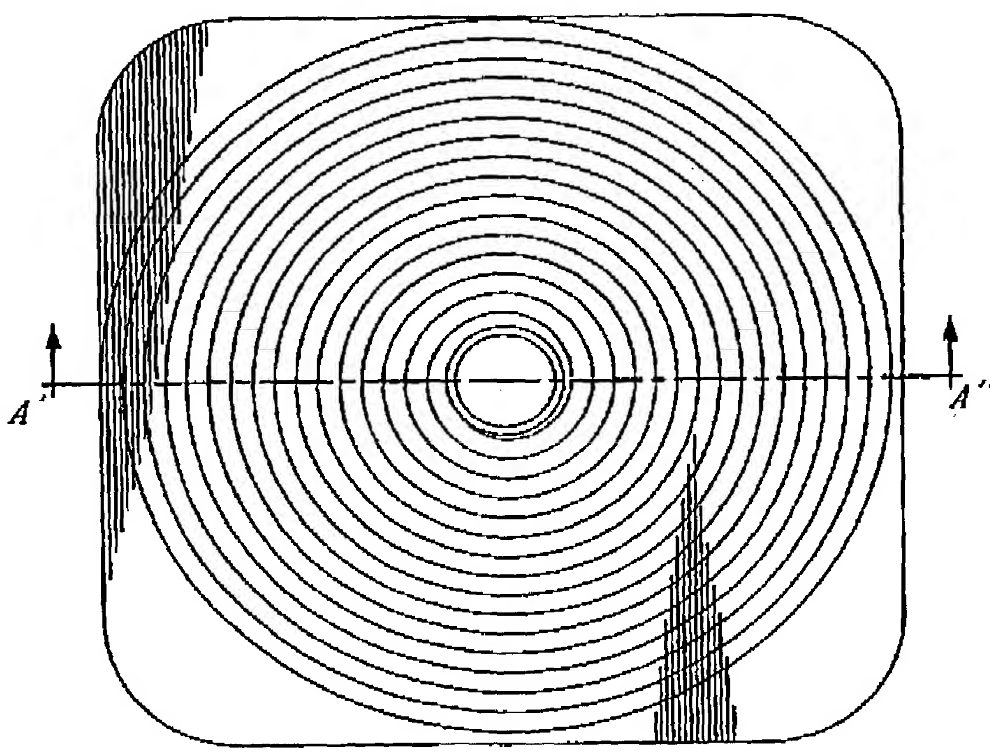

FIG. 1

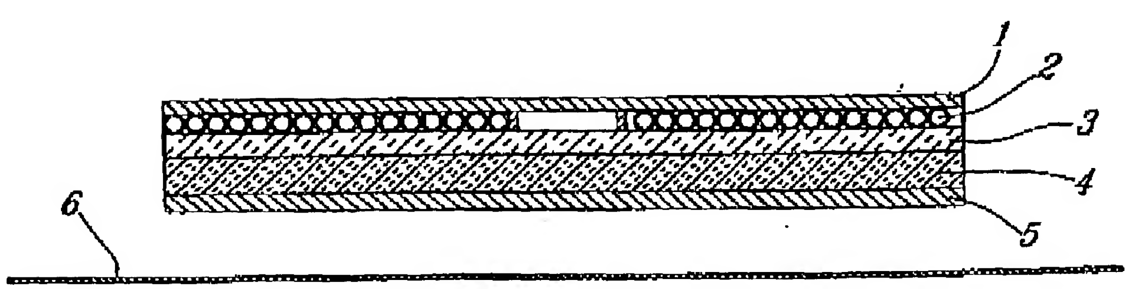

FIG. 2

218239US2PCT

Declaration, Power of Attorney and Petition

WE (I) the undersigned inventor(s), hereby declare(s) that:

My residence, post office address and citizenship are as stated below next to my name,

We (I) believe that we are (I am) the original, first and joint (sole) inventor(s) of the subject matter which is claimed and for which a patent is sought on the invention entitled

INFRARED HEATER WITH ELECTROMAGNETIC INDUCTION

the specification of which

☐ is attached hereto.

☐ was filed on ____________ as

Application Serial No. ____________

and amended on ____________.

☒ was filed as PCT international application

Number PCT/CA00/00722

on 15 JUNE 2000,

and was amended under PCT Article 19

on ____________ (if applicable).

We (I) hereby state that we (I) have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

We (I) acknowledge the duty to disclose information known to be material to the patentability of this application as defined in Section 1.56 of Title 37 Code of Federal Regulations.

We (I) hereby claim foreign priority benefits under 35 U.S.C. § 119(a)-(d) or § 365(b) of any foreign application(s) for patent or inventor's certificate, or § 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or PCT International application having a filing date before that of the application on which priority is claimed. Prior Foreign Application(s)

Application No.	Country	Day/Month/Year	Priority Claimed
2,277,885	CANADA	16 JULY 1999	☒ Yes ☐ No
			☐ Yes ☐ No
			☐ Yes ☐ No
			☐ Yes ☐ No

Received at: 10:01AM, 9/3/2002
09/03 2002 10:01 FAX 416 640 1500 OGILVY RENAULT 016

We (I) hereby claim the benefit under Title 35, United States Code, § 119(e) of any United States provisional application(s) listed below.

(Application Number) (Filing Date)

(Application Number) (Filing Date)

We (I) hereby claim the benefit under 35 U.S.C. § 120 of any United States application(s), or under § 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. § 112, I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR § 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of this application.

Application Serial No.	Filing Date	Status (pending, patented, abandoned)
PCT/CA00/00722	15 JUNE 2000	

And we (I) hereby appoint the following registered practitioner(s):

22850

as our (my) attorneys, with full powers of substitution and revocation, to prosecute this application and to transact all business in the Patent Office connected therewith; and we (I) hereby request that all correspondence regarding this application be sent to

22850

We (I) declare that all statements made herein of our (my) own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

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Signature of Inventor

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NAME OF FIFTH JOINT INVENTOR

Signature of Inventor

Date

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